Physico-chemical and nutritional evaluation of flour made from an under-utilized food crop buckwheat

Abstract

Buckwheat (*Fagopyrum esculentum* Moench) is broadly referred to as pseudo cereal among the economically important underutilized crop plants. The crop is nutritionally comparable or even superior to major cereals like rice, wheat and maize especially with respect to protective nutrients. Buckwheat is a gluten-free pseudo cereal with a high nutritional content and various health advantages that have been scientifically proven. Buckwheat flour is utilized in numerous goods that can be used to make gluten-free foods for people who are gluten intolerant. Buckwheat has been drawing more and more attention in recent years due to its benefits for human health. Buckwheat is well known for being a good source of nutritionally important protein, lipid, dietary fiber, and minerals. From a nutritional point of view, buckwheat results very interesting because of its good level of lysine, its lack of gluten for the absence of prolamin and the good protein level. The present study revealed that buck wheat is a good source of protein, fiber, dietary fiber and minerals. The moisture, ash, fat, protein, carbohydrate and energy content of buckwheat flour was found12.08, 2.33, 0.89, 12.84, 66.54%, respectively and 325.53 K cal/100g.The crude fiber and dietary fiber content was 5.38 g/100g and 18.28 g/100g. The protein digestibility of buckwheat flour was74.38% and carbohydrate digestibility was found to be low. Sodium and Potassium content of buck wheat flour was 3.7 and 66.2 mg/kg, respectively.

***Key words*:** Protein, protein digestibility, carbohydrate digestibility, physical parameters, buckwheat

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Introduction

Increasing the intake of plant-based foods offers an effective strategy for addressing global issues of undernutrition and overnutrition, along with their impacts on public health and environmental sustainability. Reliance on cereal-based diets, such as those primarily based on wheat and maize, is considered a contributing factor to malnutrition in low- and middle-income countries due to their comparatively low levels of essential amino acids. Moreover, the Western diet, characterized by highly processed and refined foods, a lack of whole grains, and high levels of sugar, salt, and fat, as well as protein sourced from red meat, contributes to metabolic disorders and obesity-related diseases. Dietary macronutrient diversification, including the incorporation of plant-based protein sources, can promote agricultural diversity, help achieve climate goals, and improve health outcomes.

Under-utilized food crops are traditional crops that are agronomically well-suited to rainfed areas, including marginal lands. These crops thrive under a wide range of environmental and soil health conditions and are often nutritionally comparable to or even superior to major cereals like rice, wheat, and maize, especially concerning protective nutrients. Given the rapidly growing population and the need for alternative food crops to ensure nutritional security, it is essential to expand our food basket. Buckwheat (*Fagopyrum esculentum* Moench) is widely recognized as a pseudocereal among economically important underutilized crop plants. It belongs to the family Polygonaceae and the genus Fagopyrum. In India, buckwheat is cultivated in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, where it is gaining popularity due to the suitable climate (Dogra and Awasthi, 2015).

In addition to Sikkim and Arunachal Pradesh, buckwheat is also commonly cultivated in the North Eastern states of Manipur, Nagaland, Meghalaya (West Khasi Hills), and in some regions of the Assam plains (Tundup *et al*., 2017). The crop is referred to in Assam by many different local names, including "Dhemchi" and "Phaphar." Although it has been cultivated in a few areas of Assam, the acreage and production numbers are not available since the crop is referred to as "coarse cereals"

Buckwheat is a gluten-free pseudo cereal with a high nutritional content and various health advantages that have been scientifically proven. Buckwheat flour is utilized in numerous goods that can be used to make gluten-free foods for people who are gluten intolerant. When combined with other health-promoting ingredients like phenolic compounds and sterols, as well as antioxidant capacity, buckwheat is gaining popularity as a potential functional food (Gimenez-Bastida and Zielinski, 2015). Buckwheat is well known for being a good source of nutritionally important protein, lipid, dietary fiber, and minerals. Such food products are made with buckwheat flour. High biological value and thiamine, riboflavin, and pyridoxine content are found in buckwheat proteins. Buckwheat is nutritionally superior in terms of fatty acid composition than cereal grains. Of the total fatty acid content, buckwheat contains 80% unsaturated fatty acids, of which more than 40% are essential linoleic acid in the flour (Skřivan *et al.*, 2023). Due to very low prolamin content in its grains, buckwheat is nutritionally intriguing. Buckwheat flour can be a valuable ingredient in diets or food products for coeliac patients due to a very low content of α – gliadin in the grains

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(Wronkowska and Soral-Śmietana, 2008). Research of the Physico-chemical and nutritional analysis of a promising buckwheat crop was attempted in light of the significance of buckwheat as a functional food given its high therapeutic and nutritional value.

Material and Methods

Grain collection

Buckwheat crop was grown in poor and less fertile land by broadcasting, with a seed rate of 40-45kg/ha. The crop was sown between September and October, and it was harvested 80 to 85 days later. The seeds (local variety) were obtained from Roing (Latitude is *28.17194 and Longitude is 95.82454*), in Dibang Valley district of Arunachal Pradesh. To remove any undesired dust particles, grains were washed carefully manually while soaking in running water. Clean grains were dried for 24 hours at 40 °C in a hot air oven (Oven Universal, hot air oven, NSW India). The remaining grains were ground to flour in a cutting miller (Retsch SM 100) and then sieved (mesh 60 mm), with one fraction of the grains being set aside for physical analysis. For further study, the flour was then stored in airtight jars.

Estimation of Physico chemical properties

Length and width

The physical characteristics (width and length) of the grains were measured with a vernier calliper (Rani *et al.*, 2020), and the crop sample was measured ten times in a row.

Bulk density

The bulk density (gcm^{-3}) of the samples was determined using the volumetric displacement method (Soliman *et al*., 2009).

Thousand kernel weight

A crop of one thousand seeds was chosen at random, and weights were recorded using an electronic digital scale. There were ten test weight replicates used.

The proximate and nutritional analyses were carried out applying the AOAC (2005) standard procedures:

Moisture

Using a hot air oven, the moisture content of grains was determined. Samples were placed in moisture dishes that had already been weighed and heated to 105°C ± 5 for one hour in a hot air oven. After removing the moisture dishes from the hot air oven and letting them cool in a desiccator, their weight was determined. Until a steady weight was reached,

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this process was repeated. The following formula was used to determine the moisture content: Moisture (%) = loss in weight (g)/weight of sample (g) × 100.

Crude protein

The Kjeldahl method was utilised to assess the protein content. Samples were processed using a two-gram digestion mixture (potassium and copper sulphates) and 10 millilitres of 96% sulfuric acid on a heated plate in a Kjeldahl flask. After cooling and filtering via Whatman filter paper, the digested sample was poured into a 100 ml volumetric flask. A distillation flask containing 5 millilitres of the digested samples and 10 millilitres of 40% sodium hydroxide was used to capture the ammonium borate that had been freed. The boric acid solution (4%) contained two to three drops of indicator (methyl red and bromocresol green). 0.1 M HCl was used to titrate the distillate that was produced.

The following formula was used to calculate the nitrogen content: nitrogen (%) = sample weight × 100/titration value × M of HCl × 14 × 100, and the protein content using the following formula: Protein crude (%) equals nitrogen (%) × 6.25.

Total fat

Using the Soxhlet extraction procedure, the total fat content was found. Weighed samples were placed in a thimble and extracted for eighteen hours using petroleum ether in a Soxhlet system. After that, the fat extract was put via a funnel in a beaker that had been previously weighed. After that, petroleum ether was evaporated, and the proportion of fat was measured by weighing the beaker.

Total ash

Ash content was determined using a muffle furnace for incineration, the content of ash was ascertained. First, weighted samples were burned on a hot plate in a preweighed silica crucible. After that, the crucible was heated to 550°C 5 for four hours in a muffle furnace. The crucible was then allowed to cool in a desiccator before being weighed. The following formula was used to determine the sample's ash content: Ash percentage = ash weight/sample weight × 100.

Crude fiber

Total dietary fibre were determined by standard methods of analysis (AOAC, 2000). Sodium and potassium contents were estimated for buckwheat flour using flame photometer method (AOAC, 1990)**.** All the results were statistically analyzed to test the significance of the results using percentages, means, standard deviations (Snedecor and Cochran, 1983).

***In vitro* protein digestibility**

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In vitro digestion of buckwheat protein was carried out according to the method described by Barbana and Boye (2013).

Results and Discussion

Physical parameters

Understanding the physical characteristics of seeds is crucial for advancing processing technology. The development of value-added products, along with the design and fabrication of specific equipment and structures used in unit operations such as handling, transport, processing, and storage, requires comprehensive knowledge of the physical, chemical, and nutritional properties of buckwheat. This knowledge is essential because buckwheat undergoes a series of unit operations before reaching the final processing stage (Unal *et al*., 2017). To characterize buckwheat, various physical characteristics were examined, including color, shape, bulk density, length, breadth, 1000-kernel weight, L/B ratio, and bulk density. The results of these investigations are presented in Table 1.

Buckwheat seeds were found to be dark to dark grey in color, with sharp edges forming a triangle shape. Buckwheat is distinguished by the shape of its seeds. According to cultivar and region-specific conditions, buckwheat's colour can range from dark brown to dark grey (Byoung et al., 2004). It was discovered that the bulk density averaged 0.65 g/ml. The larger bulk densities can be result of the grain's volume and shape.

The grain weight is an important yield contributing trait and therefore, the grain weight of buck wheat was found to be 29.68 g. Sangeeta and Grewal (2018) reported higher hundred kernel weight (2.37/100 g) and lower bulk density (0.69 g/ml) for buckwheat varieties. Variation in physical characteristics in buckwheat may be attributed to varietal differences which is influenced by the size of the grains, moisture content etc (Chandrasekaran *et al*., 2010). Length, breadth and L/B ratio of buck wheat seeds were 4.15mm, 3.25mm and 1.28. The value of length, breadth and L/B ratios of buck wheat seeds were varies depends on species.

Table 1. Physical attributes of buckwheat seeds

Sl.No	**Physical Attributes**	**Mean value**
1.	Colour	Dark grey
2.	Shape	Triangular with sharp edges
3.	1000 Kernel Wt. (g)	29.68±0.41

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4.	Bulk Density (g/ml)	0.65±0.02
5.	Length (mm)	4.15±0.85
6.	Breadth (mm)	3.25±0.41
7.	L/B ratio	1.28±0.02

Note: Values are expressed as mean ± standard deviation of three determinations.

Proximate composition of buckwheat flour

The proximate composition of buckwheat flour was analysed and presented in Table 2. Data revealed that the moisture, ash, fat, protein, carbohydrate content was found to be 12.08, 2.33, 0.89, 12.84, 66.54%, respectively and the energy content of buckwheat flour was 325.53 K cal/100g.

Table 2: Proximate composition of buck wheat flour

S.No.	Parameters	Mean values
1.	Moisture (%)	12.08±0.25
2.	Ash (%)	2.33±0.13
3.	Fat (%)	0.89±0.08
4.	Protein (%)	12.84±0.80
5.	Carbohydrates (%)	66.54 ±1.00
6.	Energy (K cal/100g)	325.53 ±1.14

Note: Values are expressed as mean ± standard deviation of three determinations.

Bhavsar *et al.* (2013) reported the mean values of moisture, fat, protein, ash and carbohydrate of buck wheat flour was 11.35%, 2.20%, 10.41%, 2.67% and 70.40 %. The lower moisture content of buckwheat flour justifies the suitability for long term storage without deterioration. Tang (2007) evaluated the proximate composition and observed that moisture, protein, lipid, carbohydrates and ash content varied from 11.0 to 11.5,15.1 to 16.3, 6.1 to 6.9, 73.3 to 74.7 and 3.5 to 3.9 per cent on dry weight basis.

A wide variation in moisture, crude protein, fat, ash, crude fibre, carbohydrates, were observed in buckwheat flour which ranged from 10.2 to10.9%, 10.1 to 15.2%, 1.6 to2.9%, 1.4 to 2.5, 6.9 to 9.3%,and 61.8 to 67.7% respectively. Comparative performance of common buckwheat revealed the satisfactory presence of crude fibre, ash, carbohydrates and protein content. Buckwheat can be used for value addition of cereals and pulses (Dogra and Awasthi, 2015).

Nutritional analysis of buck wheat flour

The buckwheat flour (BWF) was analysed for nutritional composition and the data are presented in Table3. The crude fiber and dietary fiber content was found 5.38 g/100g and

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18.28 g/100g. The protein digestibility of buck wheat flour was found to be 74.38%. Sodium and Potassium content of buck wheat flour was 3.7 and 66.2mg/kg, respectively.

Table 3: Nutritional composition of buckwheat flour

S.NO	Parameters	Mean values
1.	Crude fiber (g/100g)	5.38±0.50
2.	Total dietary fiber (g/100g)	18.28±0.48
3.	In vitro protein digestibility (%)	74.38±1.66
4.	Sodium (mg/kg)	3.7 ±0.16
5.	Potassium (mg/kg)	66.2 ±0.74

Note: Values are expressed as mean ± standard deviation of three determinations

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Crude fiber and dietary fiber

According to Mehta and Kaur (1992), crude fiber is the material that remains after food sources undergo rigorous treatment with acidic and alkaline chemicals. Dietary fiber, on the other hand, refers to the plant material in food that resists enzymatic digestion. This includes components such as gums, mucilages, cellulose, hemicellulose, pectic compounds, and lignin. Natural sources of dietary fiber encompass grains, fruits, vegetables, and nuts. Evidence suggests that fiber-rich diets offer significant health benefits (Dhingra *et al*., 2012).

High-dietary-fiber diets help reduce the risk of cardiovascular diseases by lowering LDL and plasma cholesterol levels, although they do not affect HDL or triglyceride concentrations (Schneeman, 1999). Table 3 displays the analysis results of the dietary fiber and crude fiber content in buckwheat flour (BWF). The in vitro protein digestibility of BWF was found to be 74.38%. Previous research has shown that the in vitro protein digestibility of raw flour at the intestinal phase ranges from 37.9% for millet to 78.0% for buckwheat, exceeding that of cereal-based diets (Mertz et al., 1984; Dogra and Awasthi, 2015; Fu et al., 2023). The sodium and potassium contents of BWF were 3.7 mg/kg and 66.2 mg/kg, respectively (Table 3).

In vitro carbohydrate digestibility of BWF

One of the most important strategies for preventing the consequences of diabetes is blood glucose management. As oral hypoglycemic medications, inhibitors of the enzymes that analyse carbohydrates (α-amylase and α-glucosidase) have proven beneficial in controlling hyperglycemia only in people with type-2 diabetes mellitus (Dastjerdi *et al*., 2015). α – amylase is a major enzyme responsible for breakdown of dietary starch into its by-products (oligosaccharide) which can then be broken down into absorbable monosaccharide in the intestine. Therefore, inhibiting this enzyme is seen as an active approach to diabetes treatment (Oluwagunwa *et al*.,2021)

In the present study, the *in vitro* carbohydrate inhibition activities of the buck wheat flour extract was investigated using α- amylase enzyme. IC_{50} values were calculated and the results are presented in Table 4 and percent inhibition of α- amylase enzyme activity in *in-vitro* carbohydrate digestibility was given in Figure 1. IC_{50} was obtained by interpolation of linear regression analysis from the data obtained at various concentrations. The IC_{50} value of buckwheat flour (BWF) was better than the standard maltose. This implies that consumption of buckwheat flour inhibits α- amylase enzyme activity thereby extending the total carbohydrate digestion time, leading to a decrease in the rate of glucose absorption and therefore reducing the post prandial plasma glucose rise.

Table 4. Inhibitory activity of BWF against α - amylase

S. No	Parameter	BWF	Maltose
1.	IC_{50}	40.13±0.07	55.32± 0.04
2.	Mean	51.80	47.91
3.	S.E of mean	0.57	7.34
4.	C.D	1.30	1.01
5.	C.V (%)	1.32	1.14

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by a common letter do not differ significantly at $p \leq 0.05$.

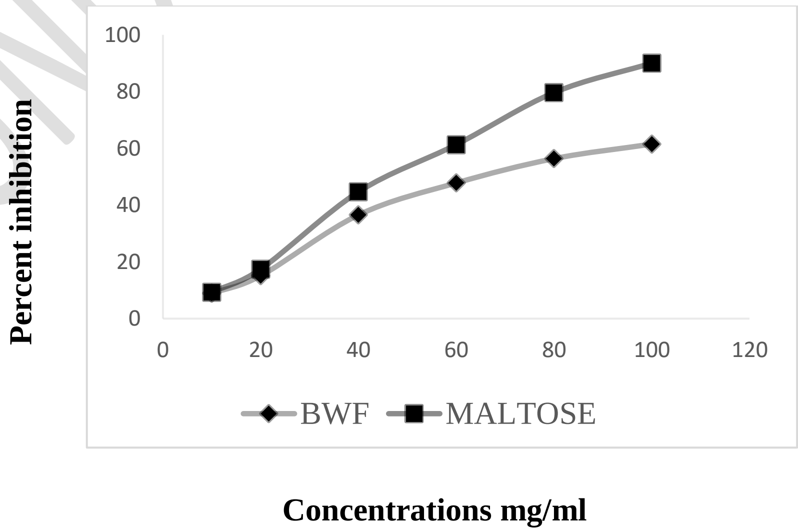

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Fig1. Percent inhibition of α- amylase enzyme activity in *in-vitro* carbohydrate digestibility

Conclusion

In conclusion, the chemical and nutritional composition of buckwheat flour (BWF) demonstrates its potential as a valuable food ingredient rich in protein, fiber, dietary fiber, and essential minerals. The low starch digestibility of BWF suggests a beneficial role in managing blood glucose levels, making it a suitable component for foods aimed at improving health and nutrition. Incorporating BWF into various food products can enhance their functional and nutraceutical properties, contributing to a healthier diet. To fully leverage the benefits of BWF, further research is necessary to explore its applications across a diverse range of food products, thereby unlocking its full potential as a high-value ingredient in the food industry.

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